

An Adaptive Cloud Motion Field Using the LETKF in Conjunction with a Numerical Weather Model, Satellite Images, and Optical Flow

**Travis Harty
Program in Applied Mathematics
University of Arizona**



RESEARCH, DISCOVERY & INNOVATION

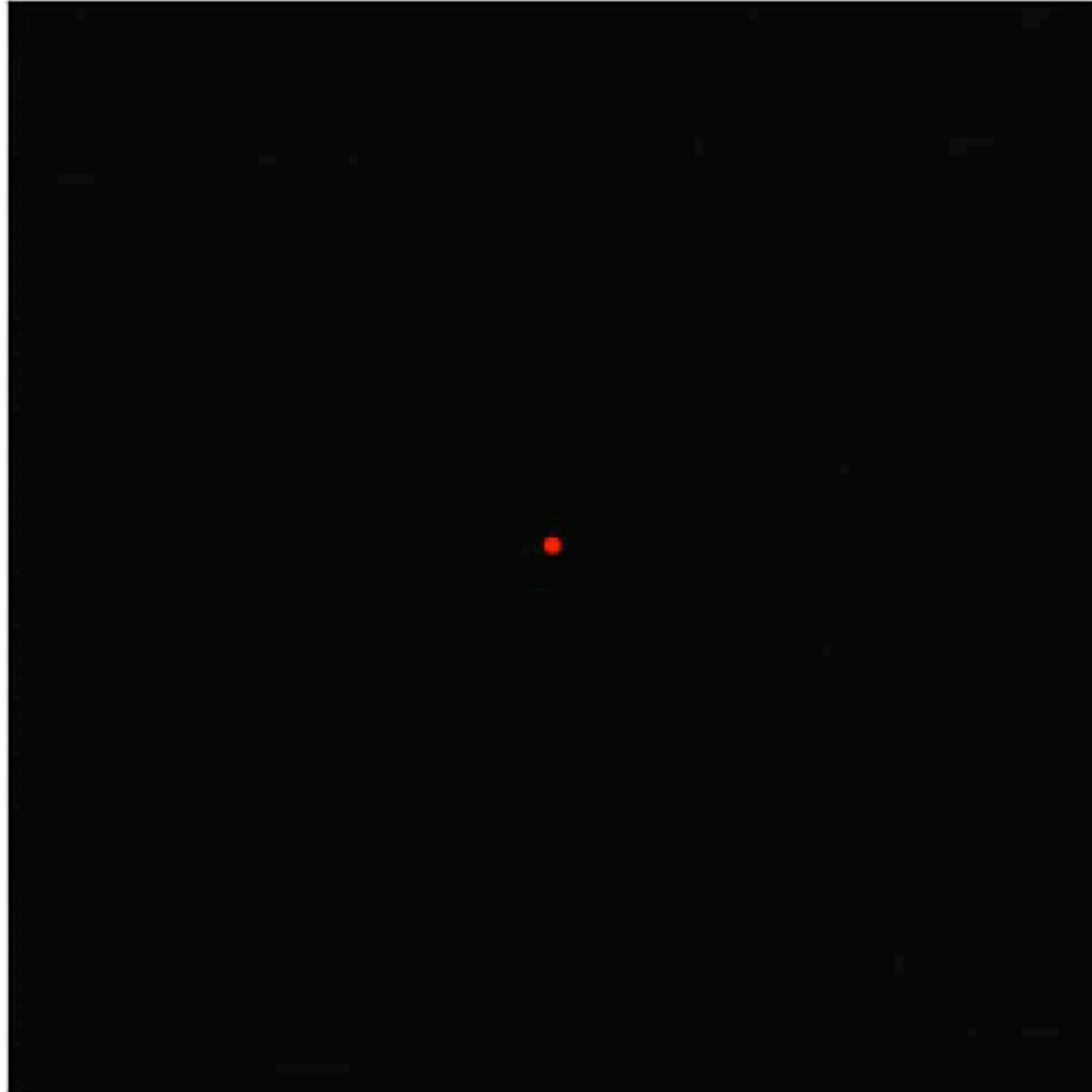
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aps



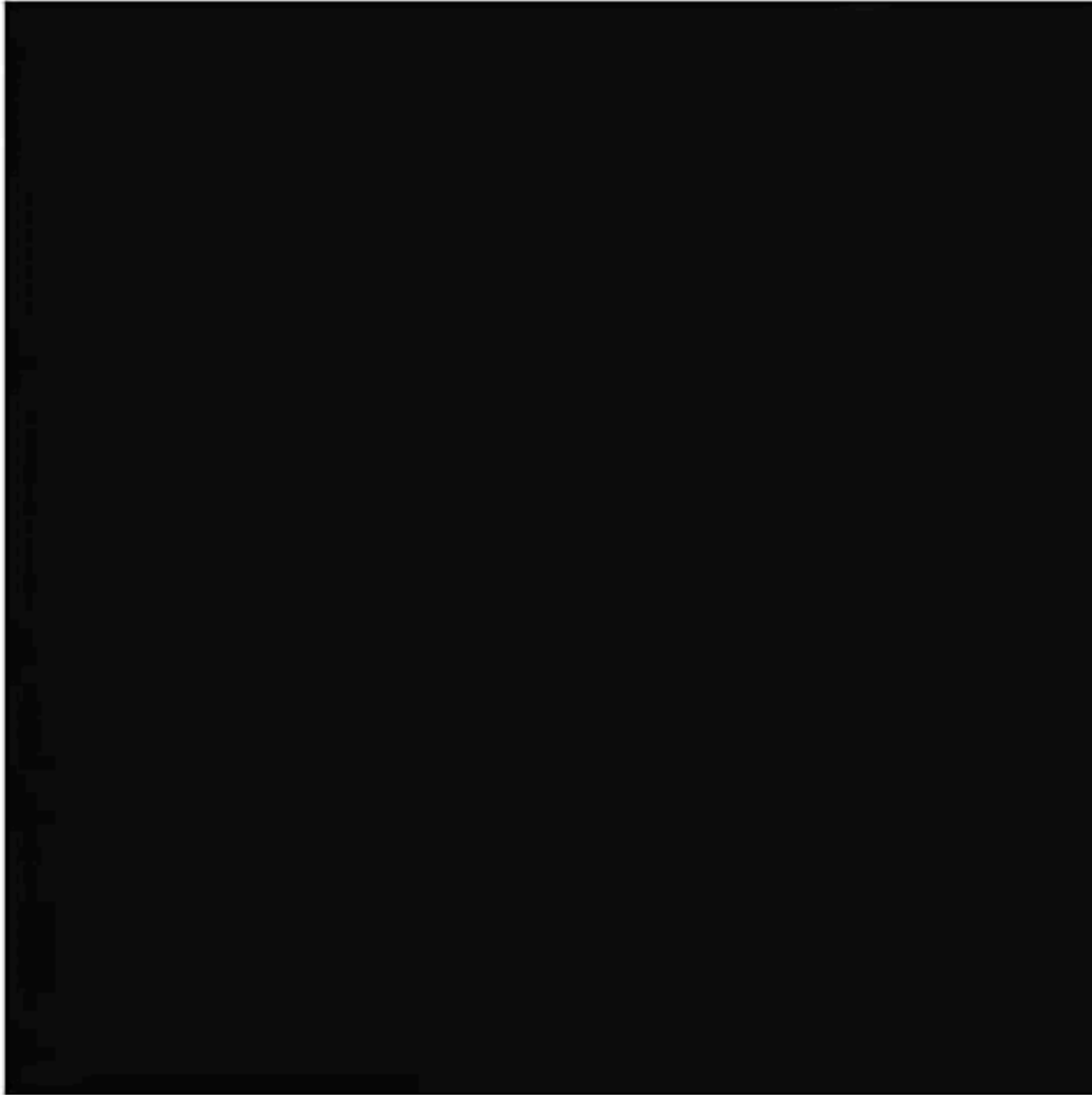
Satellite based irradiance forecasting



- Convert satellite images to irradiance
- Create forecasts based on a cloud motion field
- Short term irradiance forecasts (minutes to hours)

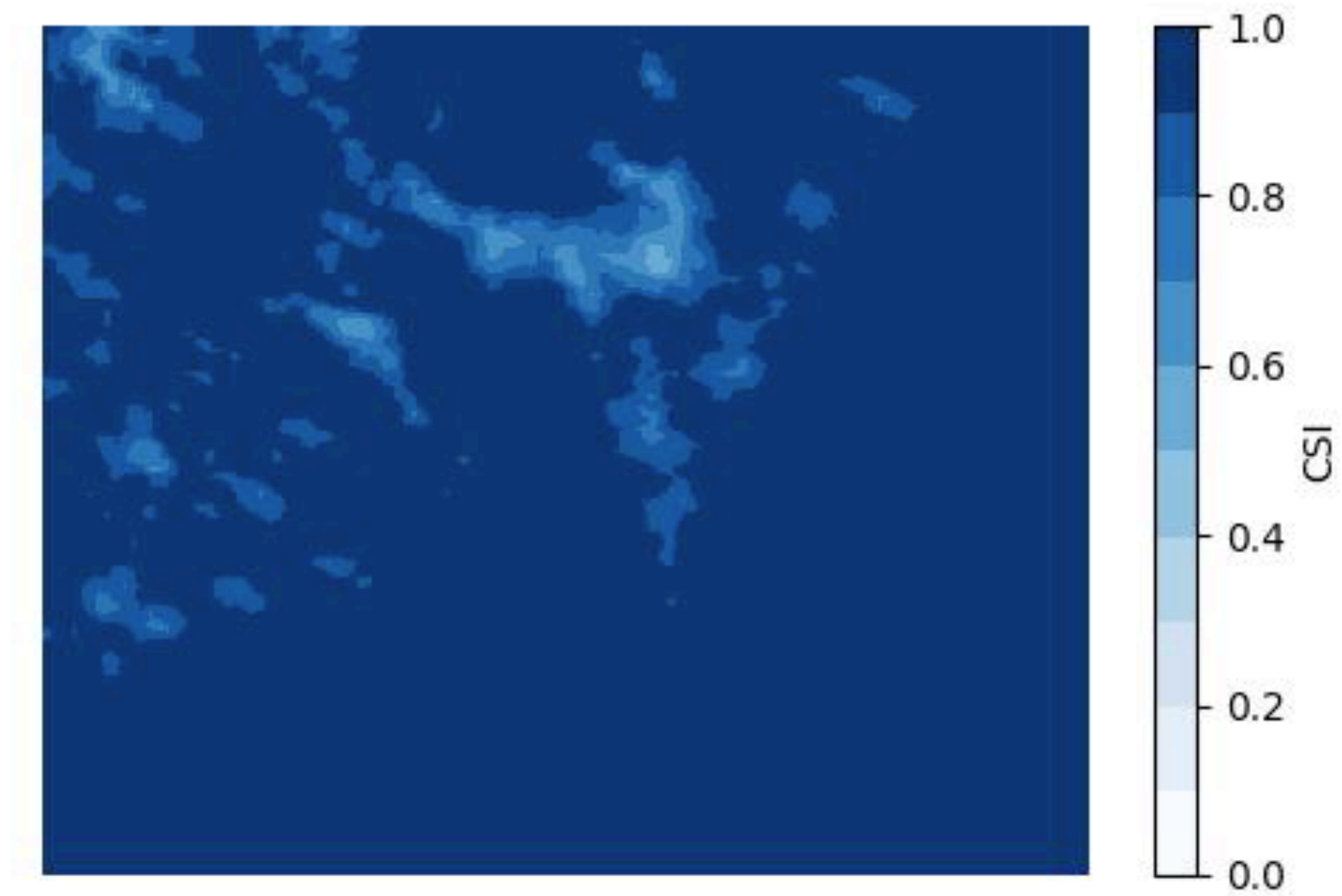
Satellite images

time: 2014-04-15 06:00:00-07:00

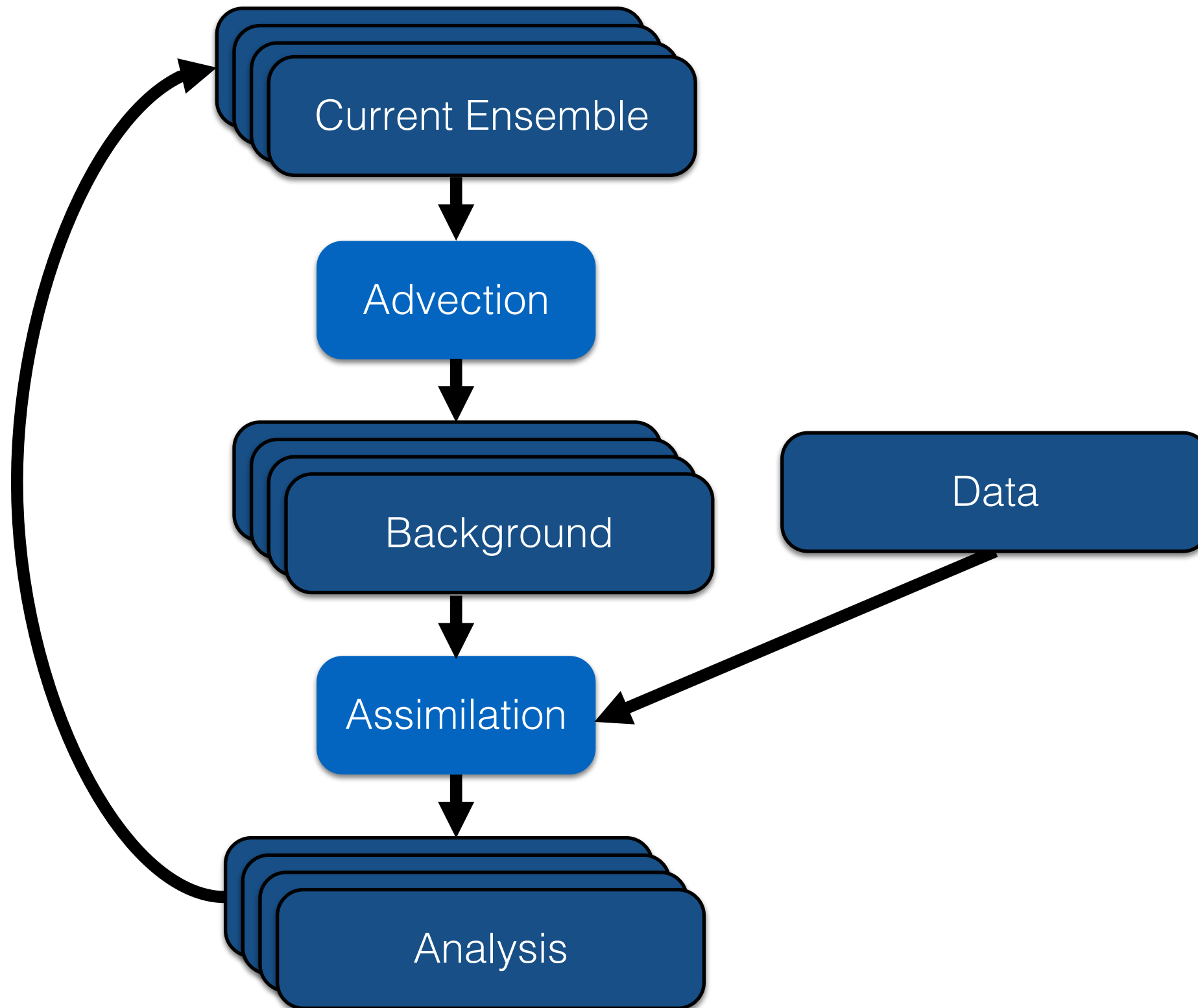


- Geostationary satellite images (GOES-15)
- Available every 15 minutes
- Spatial resolution of 1 km²
- Converted to clear sky index (normalized irradiance)

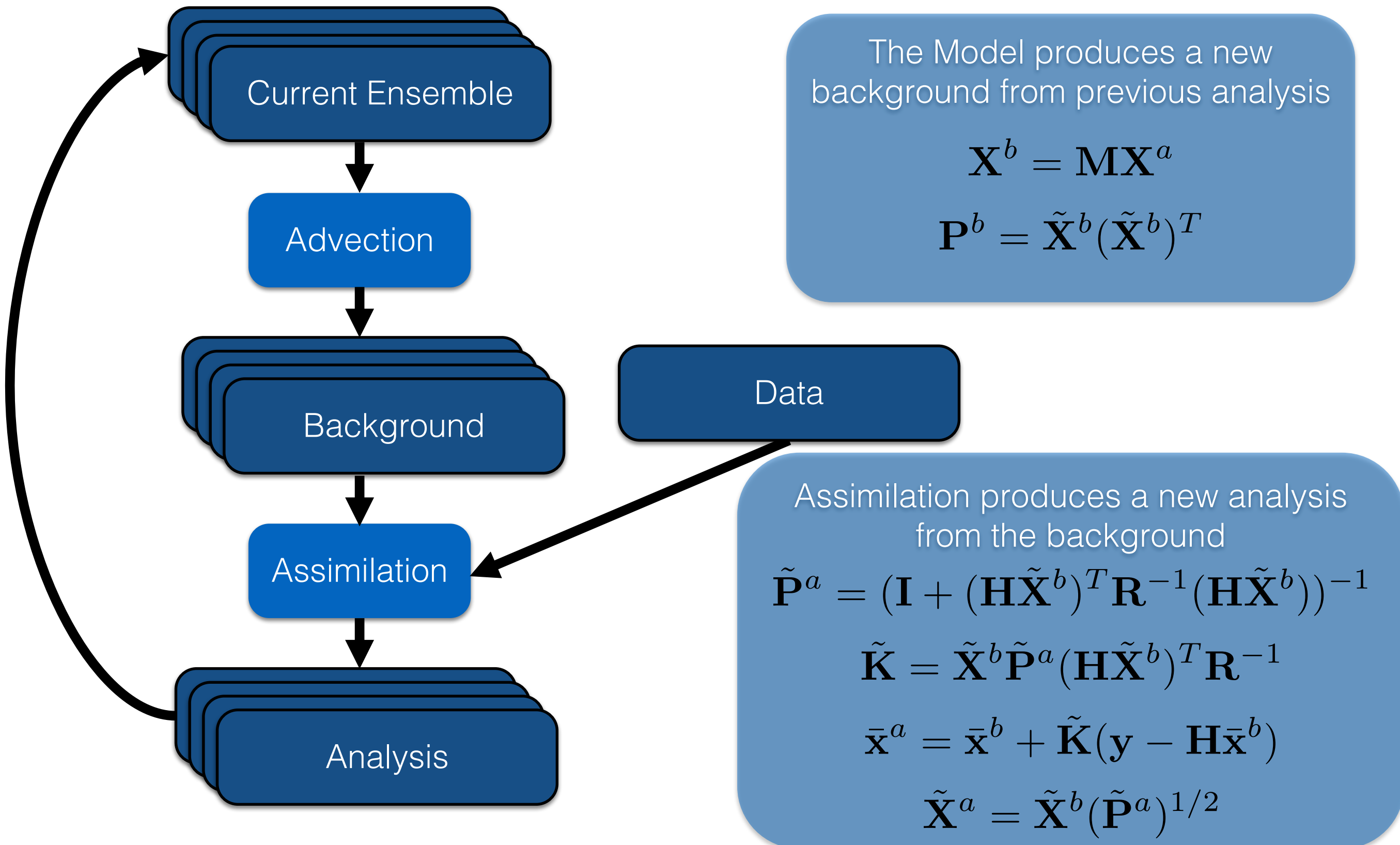
Example forecast



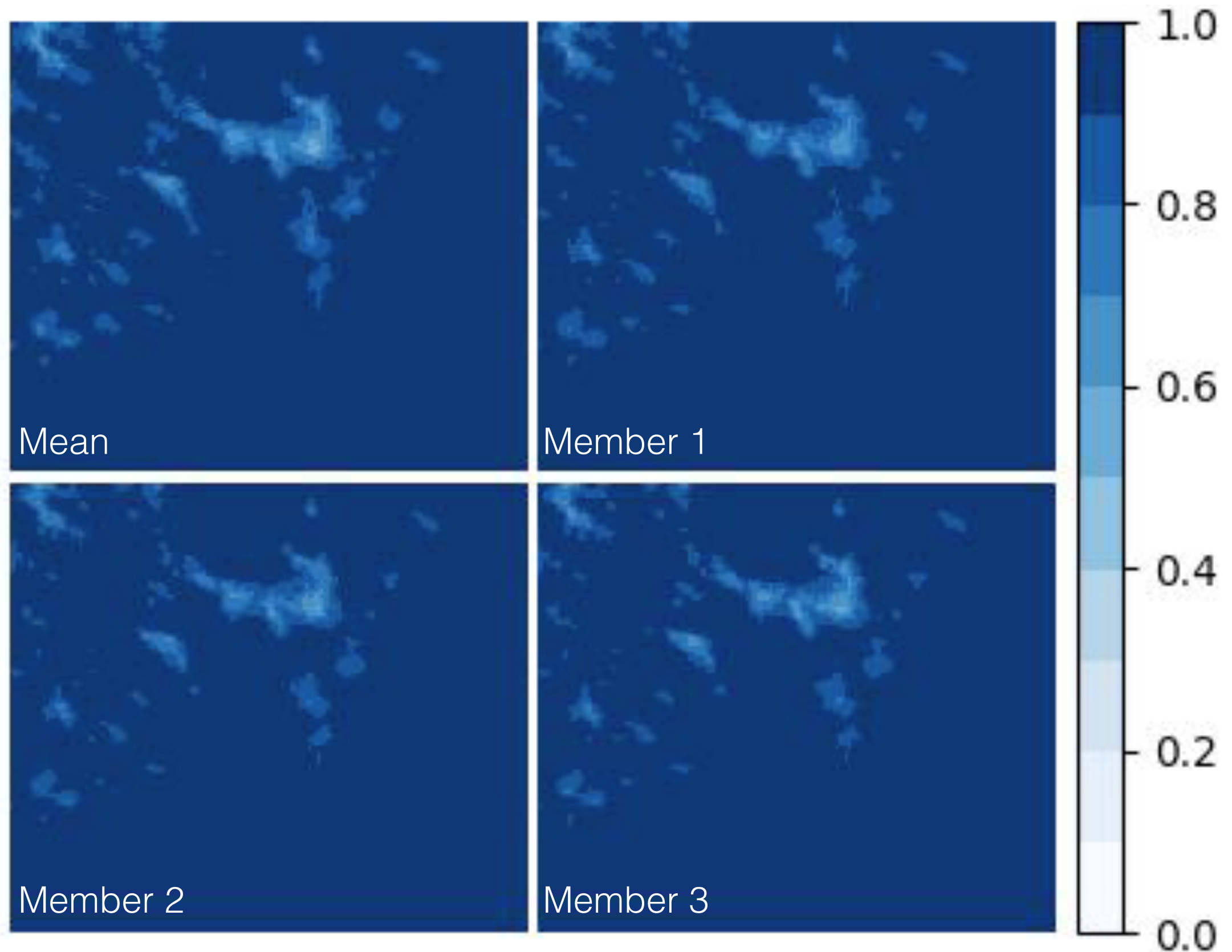
Ensemble data assimilation



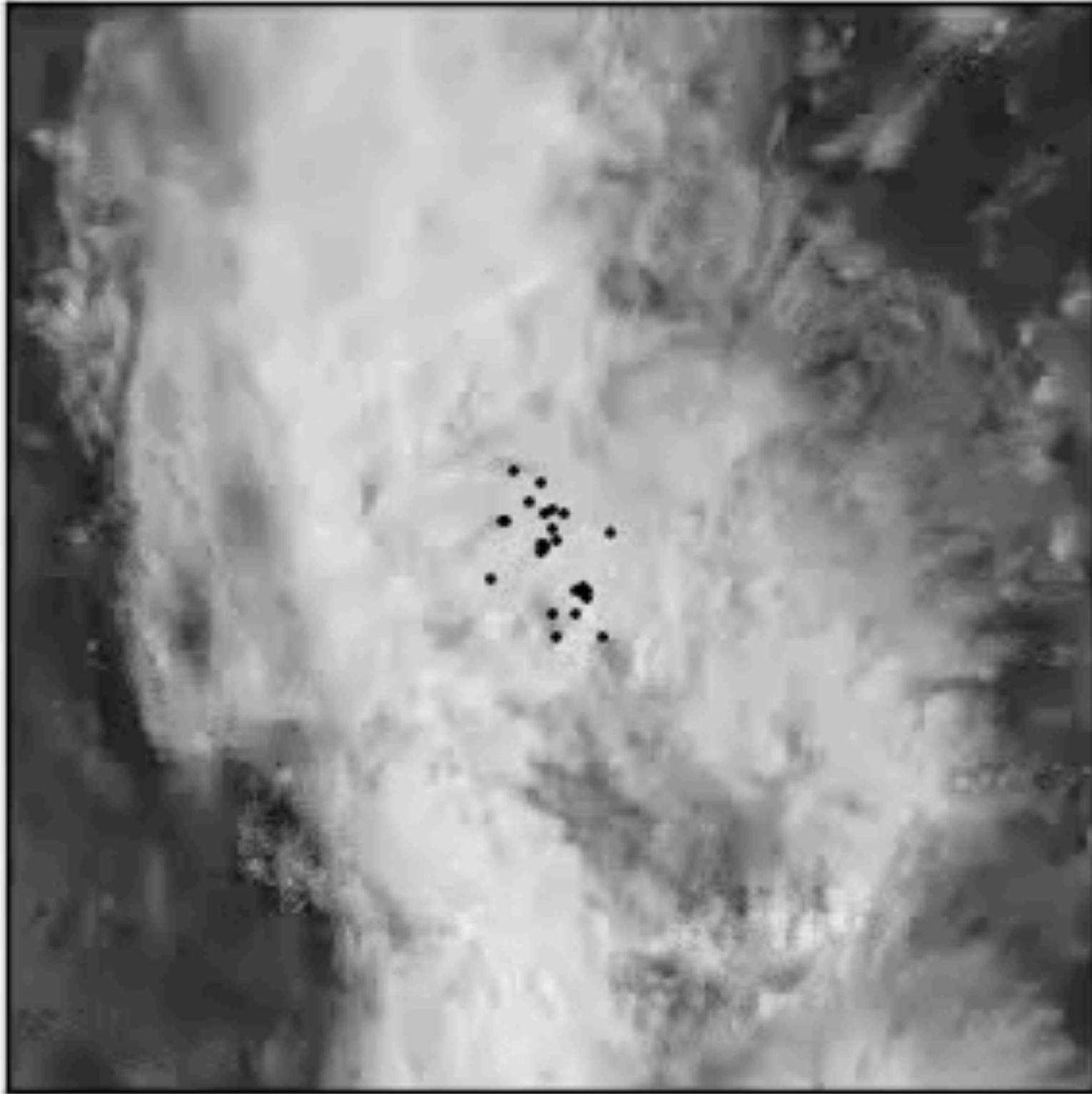
Data assimilation (LETKF)



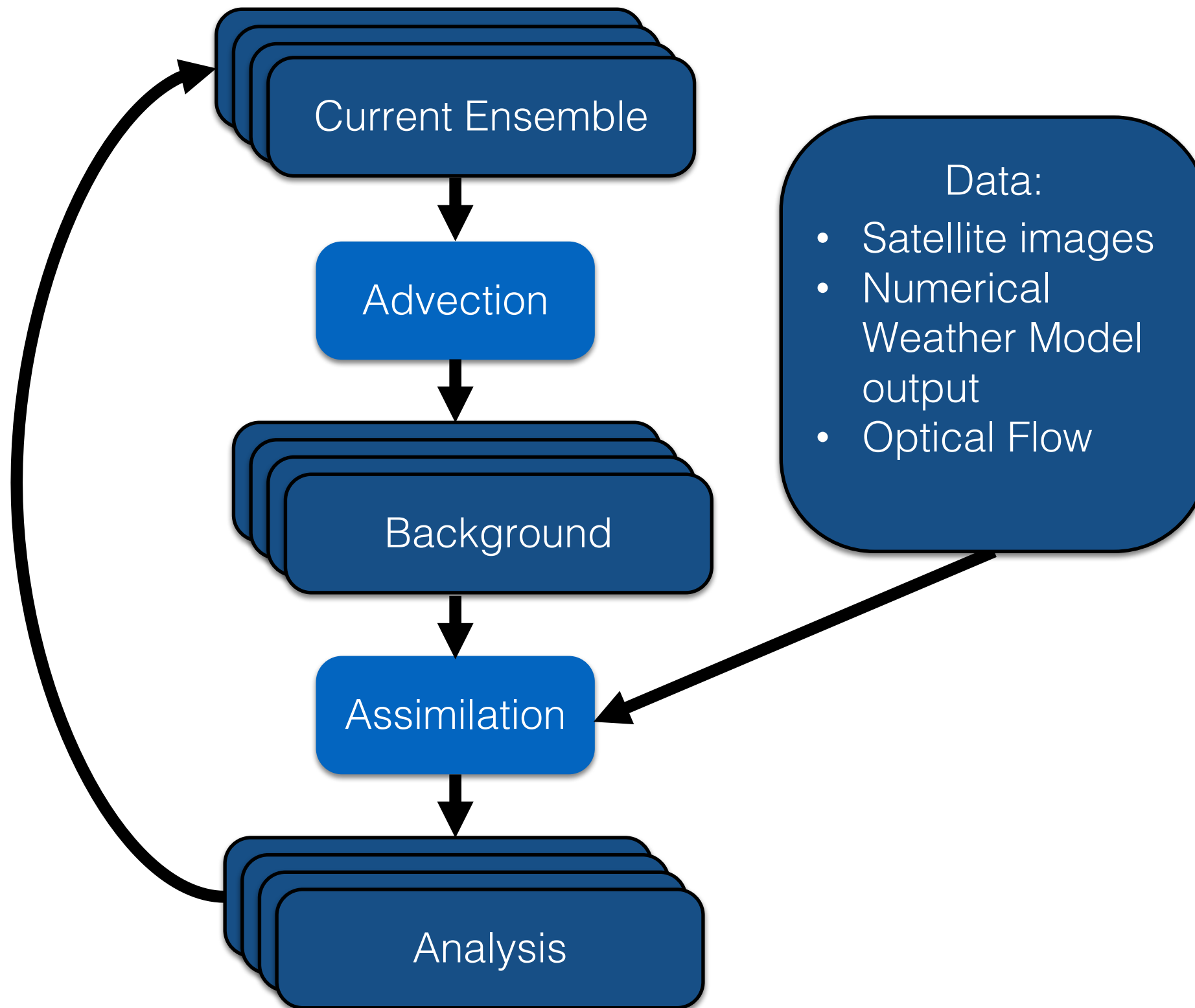
Ensemble of perturbed CSI fields



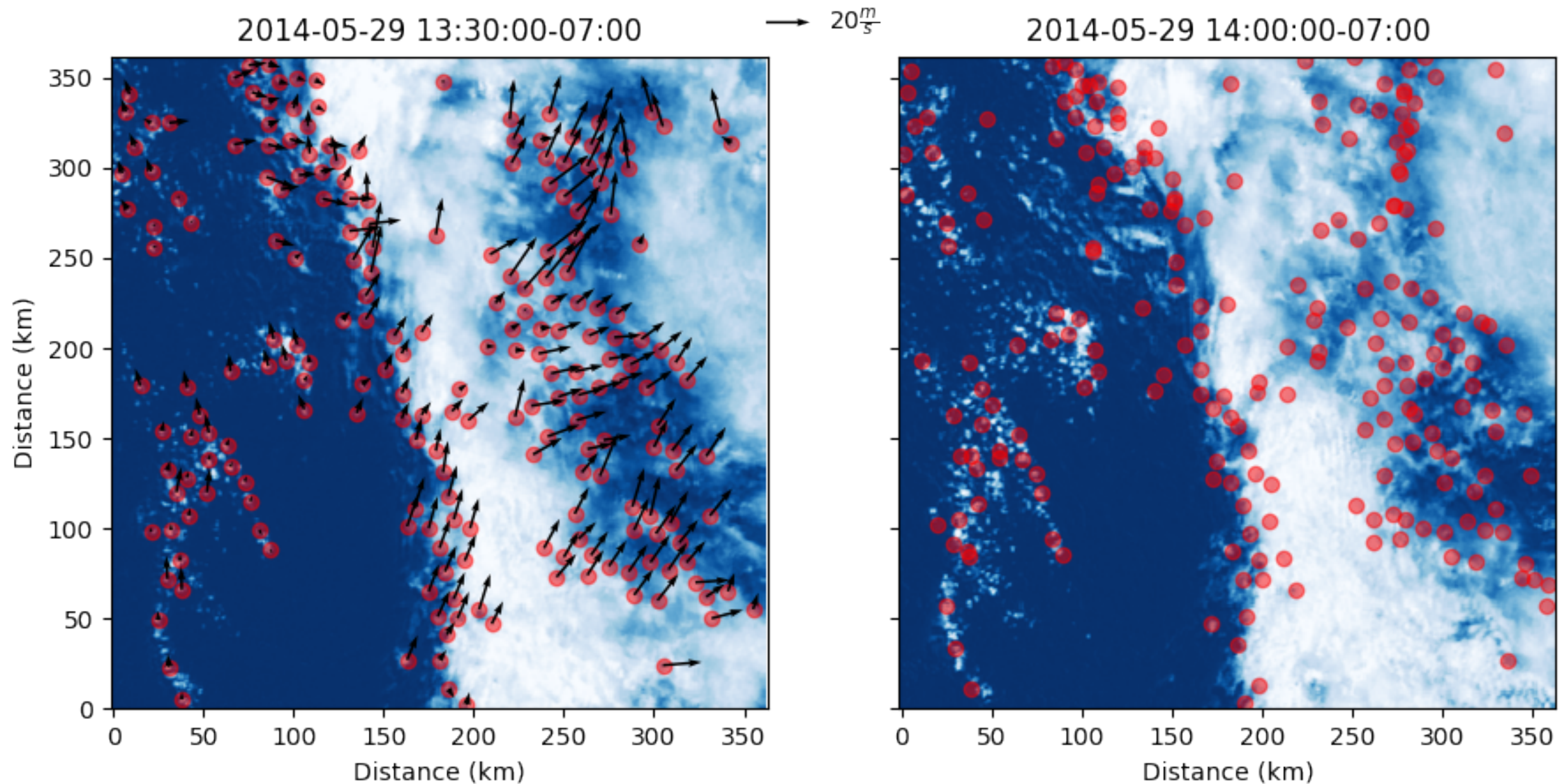
A complex day



Types of data

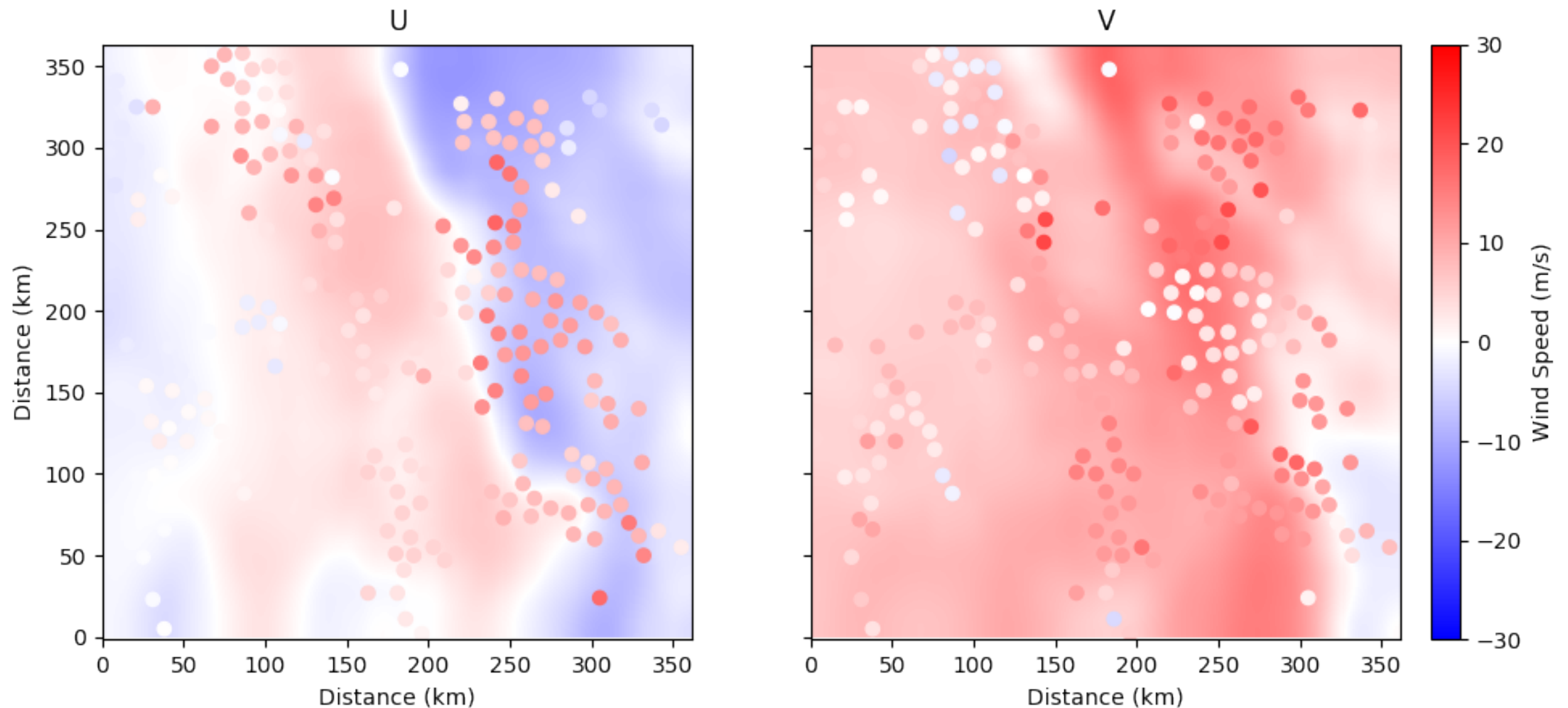


Optical flow



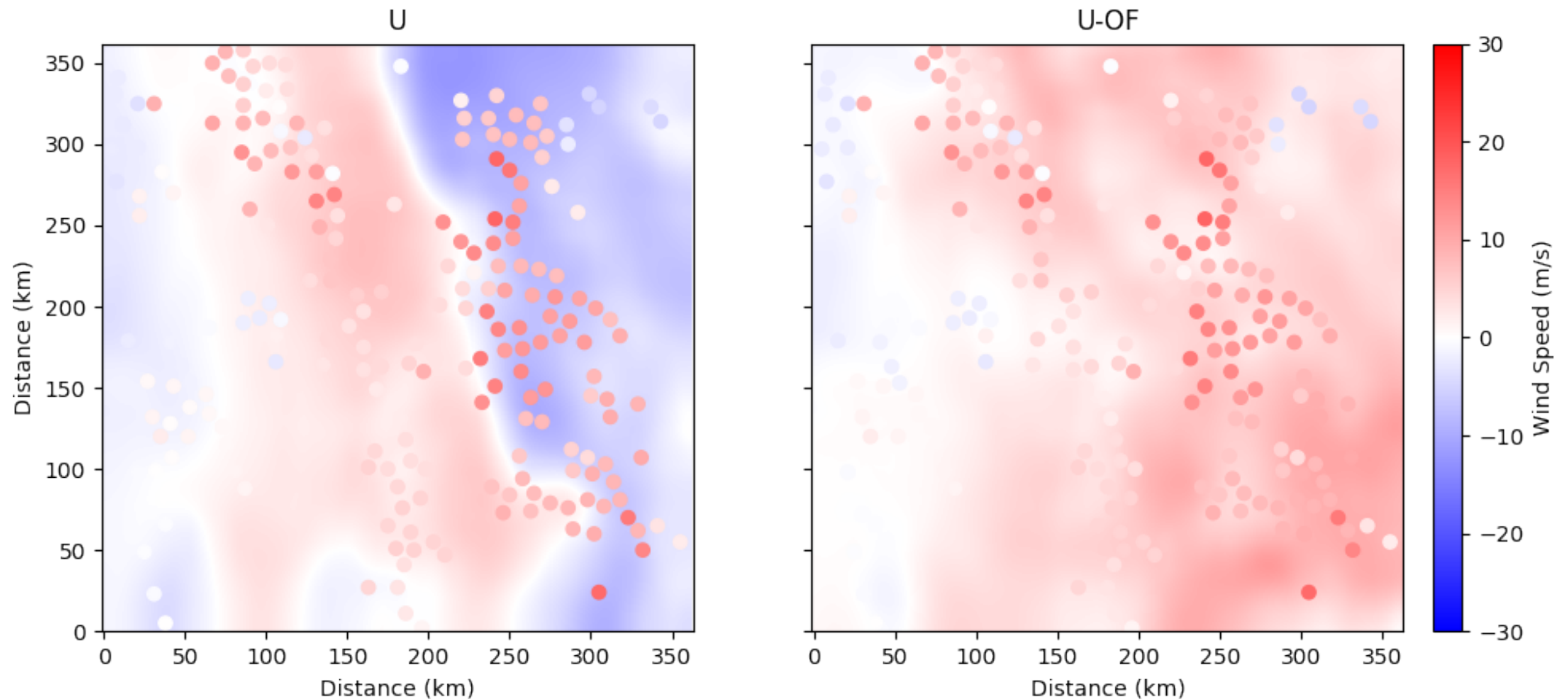
- Choose features on the satellite image based on the gradient of the image and the image's windowed variance
- Track features to estimate the cloud motion field

Wind observation



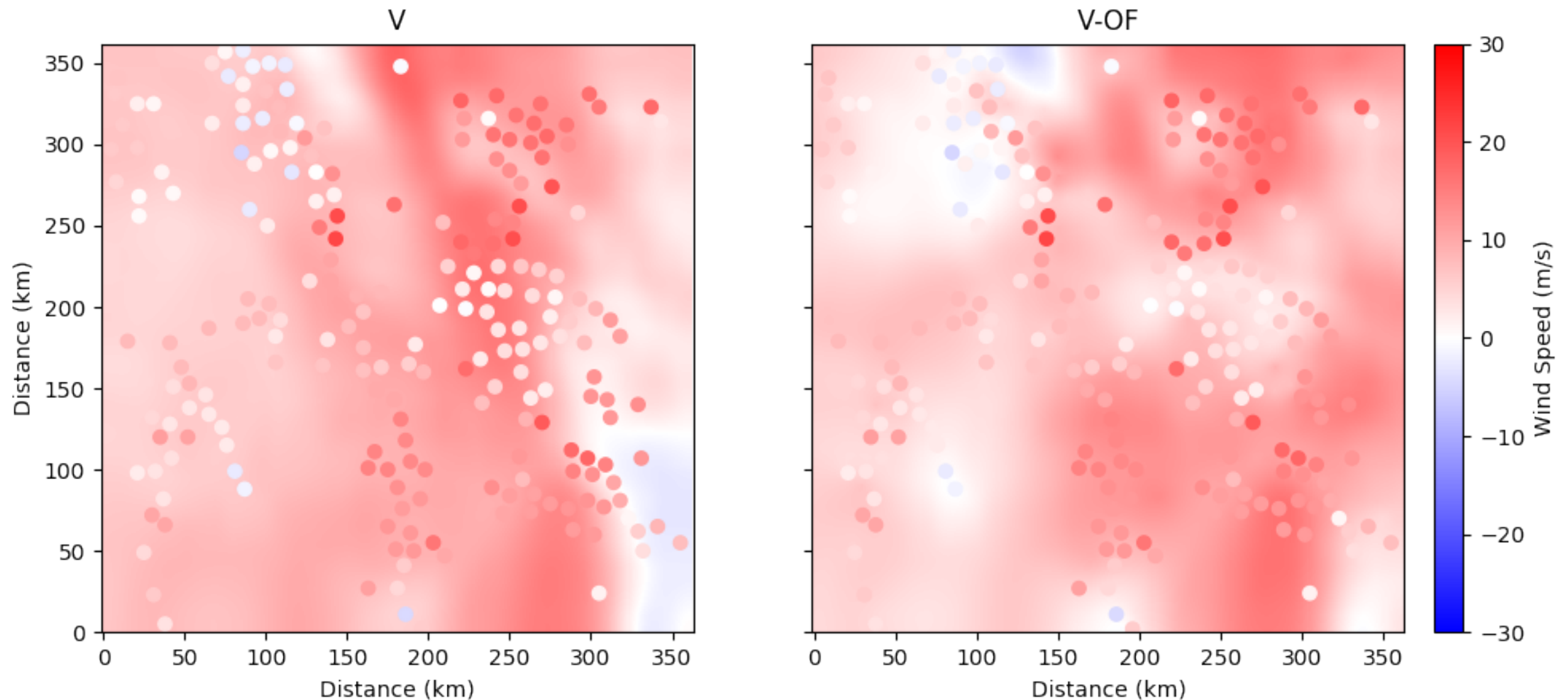
- The resulting vectors (scatter plot) can be thought of as observations of the cloud motion field
- These can then be assimilated into the cloud motion field derived from a numerical weather model (background)

Assimilate optical flow data



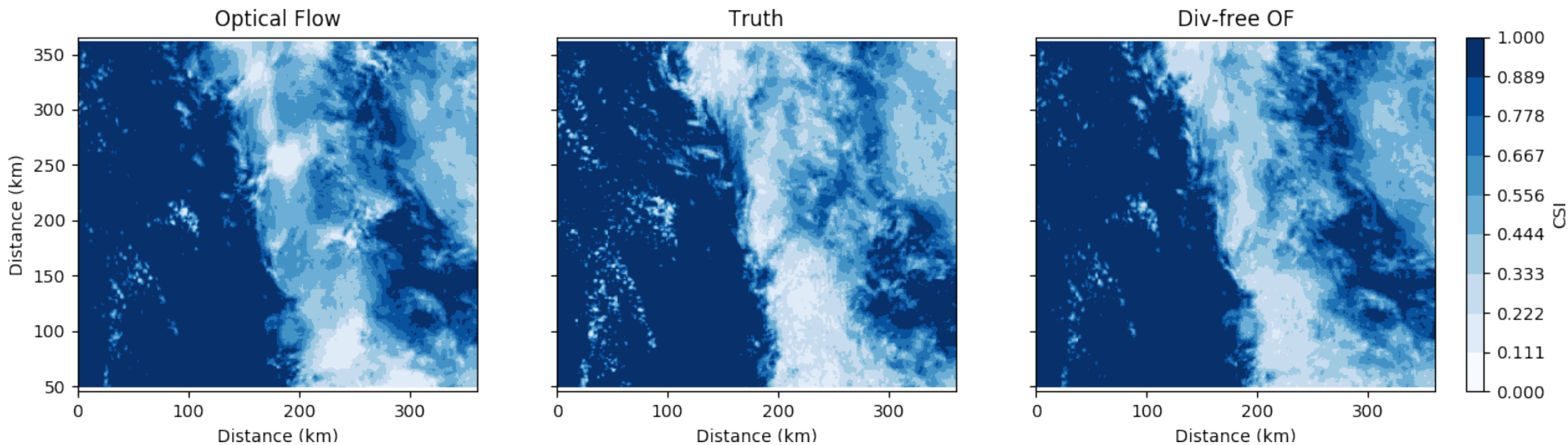
- Assimilate optical flow to improve cloud motion field
- The analysis cloud motion field has greater agreement with our optical flow vectors

Assimilate optical flow data



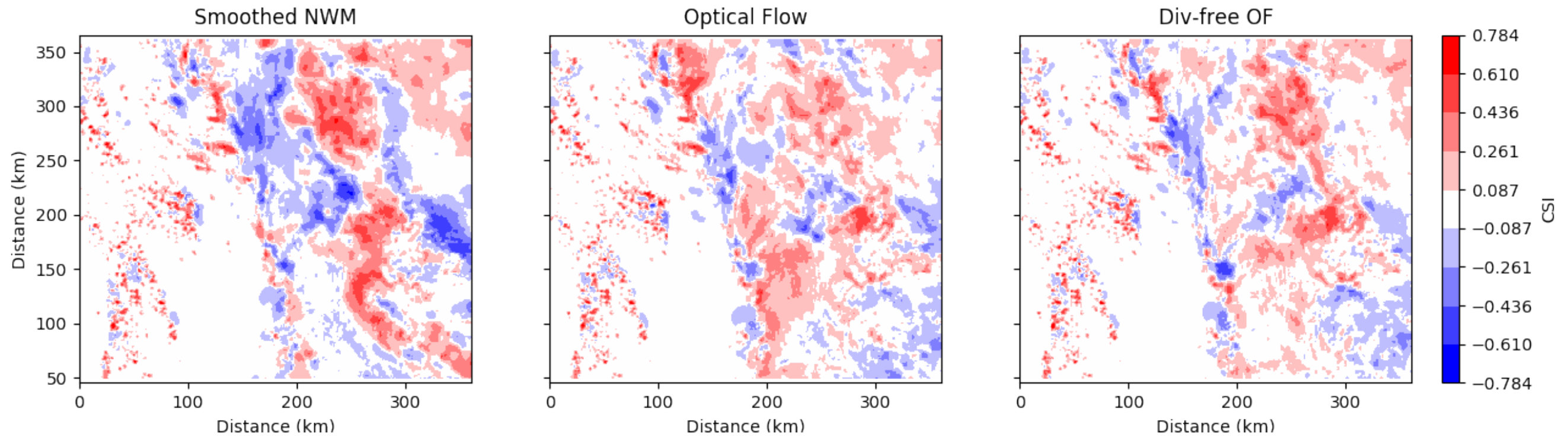
- Assimilate optical flow to improve cloud motion field
- The analysis cloud motion field has greater agreement with our optical flow vectors

Forecasting with optical flow



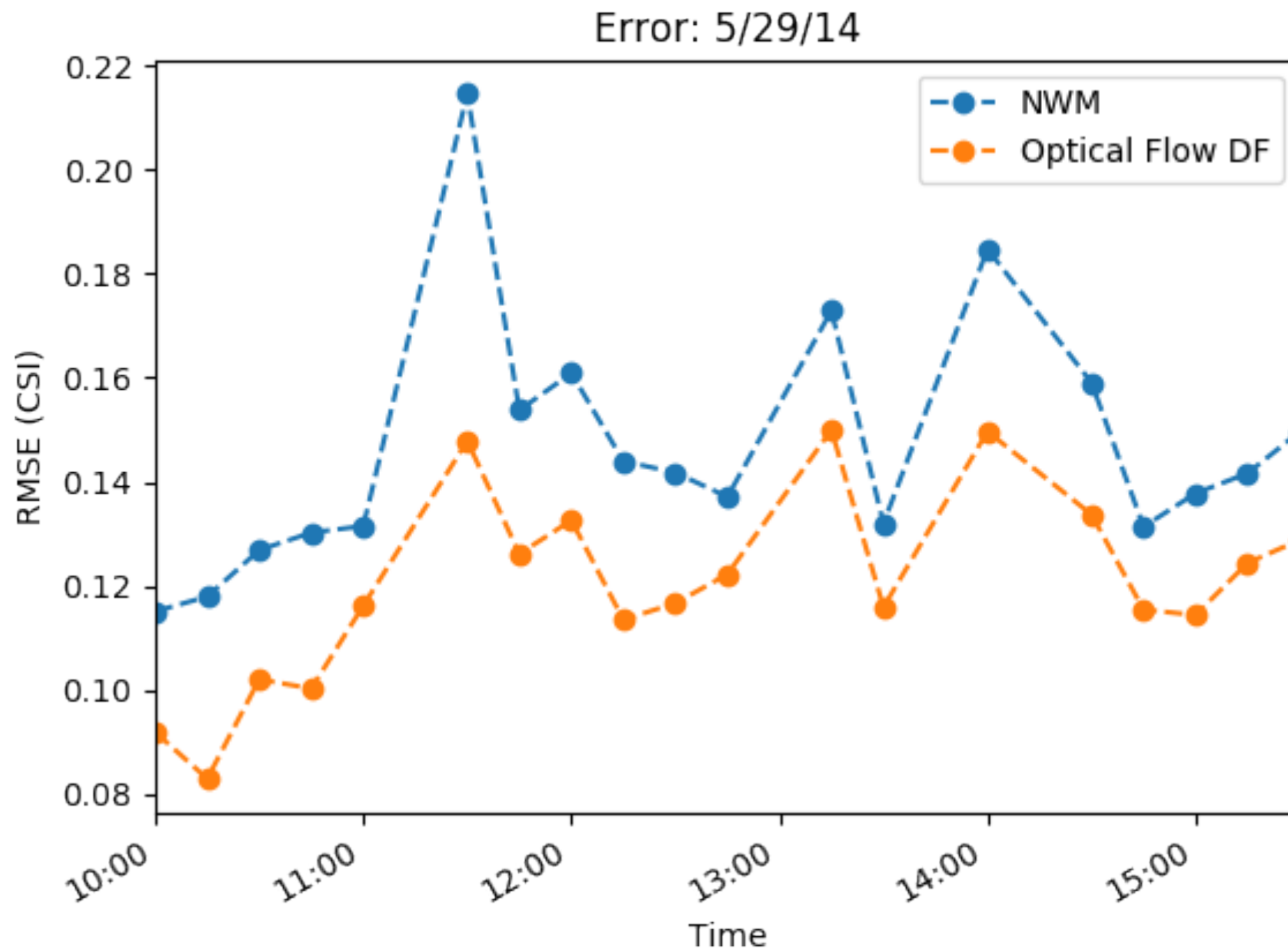
- Assimilate optical flow to improve wind field
- Removal of divergence further reduces error and improves

Error fields for successive steps



- Error is reduced when optical flow vectors are assimilated
- Reduced further once divergence is removed

Time series of Error



**Day's average
RMSE:**

NWM Cloud
Motion Field:
0.146

Optical Flow DF:
0.120

RMSE is consistently reduced by assimilating optical flow and removing divergence

Conclusion & Future Work

Conclusions:

- Ensemble data assimilation scheme to make irradiance forecasts
- Optical flow vectors to handle complex cloud motion fields

Future Work:

- Combine optical flow methods with LETKF
- Characterize weather conditions to determine parameters

Thank you!



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